Scalable Scientific Computing Software Research

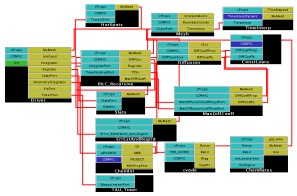
SCALABLE SOFTWARE CONSTRUCTION

- Software construction is complex, multiplayer, and multiyear.
- Run-time efficiency still matters.
- Innovation is required in hardware, algorithms, and software development.

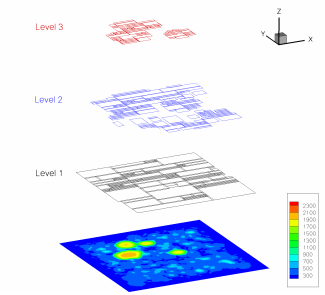
Application interests:
Hydrodynamics, linear algebra, component deployment, and compiler technology.

Common Component Architecture (CCA)

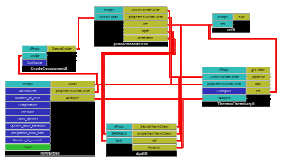
Port interfaces allow scientists to code independently and reuse high performance code from others.



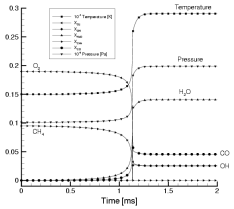
Combustion with SAMR



ODEPACK++ components in an AMR application

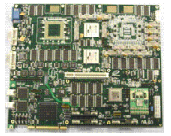


0-D ignition simulation with detailed chemistry (CH_4-Air)



TOWARD PETAFLOP ARCHITECTURES

Scientific Computing with Streams



***Challenges*:**

- Memory hierarchy
  - Latency
  - Bandwidth
  - Network
- Mean time to failure
- I/O

***Hardware*:**

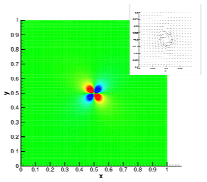
- Linux Clusters
- SMP Clusters
- Merrimac (Stanford Univ.)
- TRIPS (UTA / IBM)
- X1 (Cray)

Source code portability across range of parallel architectures requires:

- MPI
- Exposing parallelism of fine grained operations.
- Compilers that map parallelism to hardware.

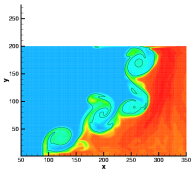
Brook: Streaming Extensions to C

```
kernel void DotProduct(double x<>, double y<>, reduce double product) {
    product += x*y ;
}
```



Stencil operations computing field of Osseen vortex

- Alpha testing Stanford and Reservoir tools on problems of interest:
  - Stenciled algorithms
  - Block matrices
  - Sparse matrices
  - Fluid shock hydro
  - Solid mechanics
- Allow evolutionary approach to code change.
- May be better than OpenMP.

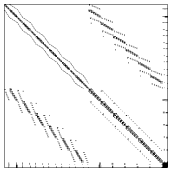


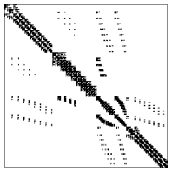
Vortex sheet roll-up at an irregular gaseous interface accelerated by a Mach 10 shock

SYNTHESIS

Create CCA components with Brook cores.

Trade-off: software engineering scalability vs parallel performance.





Brook prototypes for solution algorithms on blocked, sparse row, and sparse column matrix format

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